

GENERAL DYNAMICS/ASTRONAUTICS

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SPACE SCIENCE LABORATORY

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DEVELOPMENT OF A COAXIAL PLASMA GUN
FOR SPACE PROPULSION

Monthly Progress Report
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During the past month the Mark VIII gun has been assembled using the new Axel capacitors. This gun was designed to accommodate 24 capacitors, each approximately $0.4 \mu\text{f}$, with 17 nanohenries inductance. So far we have received only 23 units, and had two failures so the gun has been installed with 21 units, giving a total capacity of $8.6 \mu\text{f}$. The total inductance of the capacitors, transmission line and insulator is less than 1.5 nh.

The gun has been operated for the past few weeks at a repetition rate of one shot every 10 seconds. A preliminary survey of the magnetic and electric fields in the gun has been completed using the remotely controllable probe carriage. The field distributions are similar to those obtained with the Mark V gun, except that the magnitude of B_θ is higher because of the higher C and lower L. The axial electric field is, as before, too small to accelerate the ions to the current-sheet speed. The current waveform is considerably more asymmetric than in the earlier guns, which indicates more kinetic motion of the plasma at early times. Voltage and current measurements have been made to determine the power input to the gun. These preliminary results look promising and suggest that the higher C and lower L is producing the desired effect;

however, we suspect that a further increase in C, by a factor of two or three may be necessary before high efficiency can be achieved.

The Mark VII gun is being assembled using 15 capacitors each of 0.8 μ f and 7 nh. The units were designed to replace the Sangamo capacitors, which had previously been rejected because their inductance was three times the design value (25 nh). This gun will be used exclusively for low repetition rate studies, in the small vacuum chamber.

Velocity measurements were made on the Mark VI gun, using the electrostatic article analyzer, during the period April 15th to June 1st. The measurements showed that the bulk of plasma was singly ionized nitrogen, moving at average velocity of about 7 cms/ μ sec or 70% of the sheet velocity. A second group of singly ionized nitrogen ions was observed at twice the sheet velocity and a third group of very high velocity ions appeared to originate at about the time the current sheet passed the muzzle of the gun. This fast component has been reported by the Los Alamos group, and attributed to a pinch or instability occurring off the end of the inner barrel.

These measurements were interrupted in order to build an improved version of the analyzer, and to begin studies with the Mark VIII gun. A large test facility has been constructed by General Dynamics/Astronautics, and vacuum tested to less than one micron pressure. The system seems to have only one major leak, but to further enhance its capability two minor tank modifications are being made. These changes will be completed shortly and we expect to be running the Axel gun in this tank within two weeks.

During the next month we will continue probe studies and voltage measurements on the Mark VIII and Mark VII guns. In addition a

systematic study will be made, varying voltage, propellant species and gas distribution, to determine the optimum arrangement for maximum "efficiency", using a large copper calorimeter. We will then re-examine the optimized arrangement to study the physical processes involved in the optimized system.

A new capacitor has been designed and will be fabricated during the next month. This unit will have a capacity of about 20 μ f, and a source inductance of less than 3 nh. The unit is in the form of a single torus 24" O.D., 19" I.D. and 12" in length. This design is a first attempt at a light weight, compact unit, suitable for impulse measurements.

Cumulative funds projected - Contract NAS - 2594

(Includes Cost, Commitments and Fee)

